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SMART INSTRUMENTATION DEVELOPMENT AT LOS ALAMOS

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ABSTRACT

For several years Los Alamos has incorporated microprocessors into instruments to expand the capability of portable survey type equipment. Beginning with portable pulse height analyzers, the developments have expanded to small dedicated instruments which handle the measurement and interpretation of various radiation fields. So far, instruments to measure gamma rays, neutrons, and beta particles have been produced. The computer capability built into these instruments provides significant computational power into the instruments. Capability unheard of a few years ago in small portable instruments is routine today. Large computer-based laboratory measurement systems which required much space and electrical power can now be incorporated in a portable hand-held instrument. The microprocessor developments at Los Alamos are now restricted to radiation monitoring equipment but can be expanded to chemical and biological applications as well. Applications for radiation monitoring equipment and others are discussed.

INTRODUCTION

For several years, Los Alamos has taken a lead in the development of radiation monitoring instrumentation as well as portable data acquisition and analysis systems. The instruments relate to environmental and workplace monitoring, radiation dosimetry, and other areas. The development program attempts to fill present technology gaps in existing, commercially available instrumentation.

BACKGROUND

With the advances in low power microelectronics several years ago, it became possible to build sophisticated circuits which do not require much electrical power. Microcomputers were invented and the combination of microelectronics and microprocessors made possible the development of very powerful instruments for measuring and interpreting signals from various radiation fields. The first step at Los Alamos was to develop multichannel

analyzers (MCA) using microcomputers and then interface these circuits to pulse amplifiers and display circuits. Next, dedicated instruments were built around particular detectors. For example, a gamma-ray instrument was built around a NaI detector; a general purpose survey instrument was built around geiger tubes and a solid state detector. The microcomputer is the basic ingredient of all these instruments, which gives the instrument very powerful analyzing capability as the desired information is being acquired.

APPLICATIONS

In the area of radiation monitoring and radiation measurements, data acquisition and analysis instrumentation has traditionally been heavy and bulky. Many applications required one of a kind instrument packages, which were integrated from modular systems manufactured by a variety of vendors. This resulted in a very expensive and complicated final product. Pulse electronic modules and pulse height analyzers have been available and have served the laboratory environment very well. But, in the area of small portable instrumentation, not very much equipment has been available except for small portable survey type instruments. There has been a noticeable lack of small portable sophisticated instrumentation for complicated data acquisition and data analysis in the field.

At Los Alamos, our group (IT-1) has concentrated on this problem for several years. The first instruments to be addressed involved a portable MCA (Fig. 1) and small instruments incorporating MCA circuits with the front end detector and amplifier packages. Very often the application of the user involves measuring complicated radiation fields or radioactive materials and there is a requirement to analyze the data from such measurement in the field. Some analysis in the field is necessary to properly evaluate the information in the measurement in a timely fashion. Small microcomputers incorporated in the instrument package can make possible this type of activity away from the laboratory.

Several particular cases have been addressed recently. A portable neutron spectrometer / dosimeter was developed and built around a gas proportional LET counter (Fig. 2). This counter is a tissue equivalent linear energy transfer chamber commonly called a Rossi counter (Rossi and Failla, 1956). The instrument has been designed to give the user some information about the LET spectrum, as well as the dose and dose equivalent from a neutron radiation field. The main limitation of the instrument is the energy limit of the neutrons which can be detected. Low energy neutrons such as thermal neutrons and neutrons below about 100 keV show little or no response in the instrument.

Another instrument was developed to help address the problem of several different types of radiation simultaneously (Fig. 3). This general purpose instrument has three detectors and a microcomputer circuit switches to the proper detector as directed by the user. The detectors are a silicon surface barrier solid state detector, a very sensitive G-M tube and a less sensitive high range G-M tube. The instrument is useful for detecting gamma rays, beta rays, alpha particles and neutrons. The G-M tubes are used for beta and gamma rays, and the solid state detector is used for alphas and neutrons. Neutrons are monitored by detecting the recoil protons from a polyethylene radiator in front of the silicon detector. Other features, such as multichannel time storage, can be programmed into the instrument. With various software, the instrument can be programmed for just about any imagined special problem in radiation monitoring.

A portable beta-ray spectrometer/dosimeter (Fig. 4), similar to the neutron instrument described above, is currently being developed. In this case, the detector is a tissue-equivalent plastic scintillator and can be part of the instrument package or a separate unit. The energy spectrum of the betas, along with dose information, will be available to the operator.

A small wristwatch-sized dosimeter has long been a goal

of instrument designers. A prototype pocket dosimeter and a small wristwatch model have been fabricated (Fig. 5). The smaller version has incorporated hybrid electronic circuits and a cadmium telluride detector, with a microcomputer to provide a myriad of features in a small light package. A commercial version of this instrument would utilize a dedicated microelectronic circuit and would actually be the size of a modern digital wristwatch. Again, with chosen software, the features of such a device can be just about anything you desire.

Other instruments which incorporate on-board microcomputers include very compact general purpose packages to be used for such applications as field contamination monitors (Fig. 6). This package, called the "Violinist", includes a multichannel analyzer with several programmed regions of interest which can be used to analyze the energy spectrum being measured by the detector. All the calculations necessary for this analysis are performed in real time while the measurement is being performed. This general purpose instrument again can be changed with software to address several different instrument applications.

Finally, at Los Alamos, another program involves integrating several survey instruments to a position-locating system currently being provided by Motorola, Inc. Each field instrument will have a microcomputer to process information

and prepare it to be transmitted to a central processor with a larger computer. The location of each field instrument, along with its radiation reading, will be transmitted back to the central computer. The information at the central computer, including the position and radiation reading for every field instrument, will be displayed. For training purposes, the function of the field instruments is reversed and the central computer will transmit a reading for each instrument, depending on their location. This feature provides in-field simulated operation of the radiation instruments without the need for radiation sources in the field.

CONCLUSIONS

A revolution in small portable instrumentation is taking place as a result of recent developments in microcircuits and microcomputers. The future looks very bright indeed for further developments in instrumentation. Fast, low power devices will be utilized for many future developments. Even more complicated and sophisticated measurement problems in the field will be possible with these new tools.

REFERENCES

1. Rossi, H. H. and Failla, G. 1956, "Tissue-equivalent Ionization Chambers." *Nucleonics* 14, 32.

Figure 1. A portable multichannel analyzer

Figure 2. A portable neutron spectrometer/dosimeter

Figure 3. A general purpose radiation survey instrument

Figure 4. A portable beta spectrometer/dosimeter

Figure 5. A wristwatch dosimeter/dose rate meter

Figure 6. The "Violinist" instrument package

FIG 1

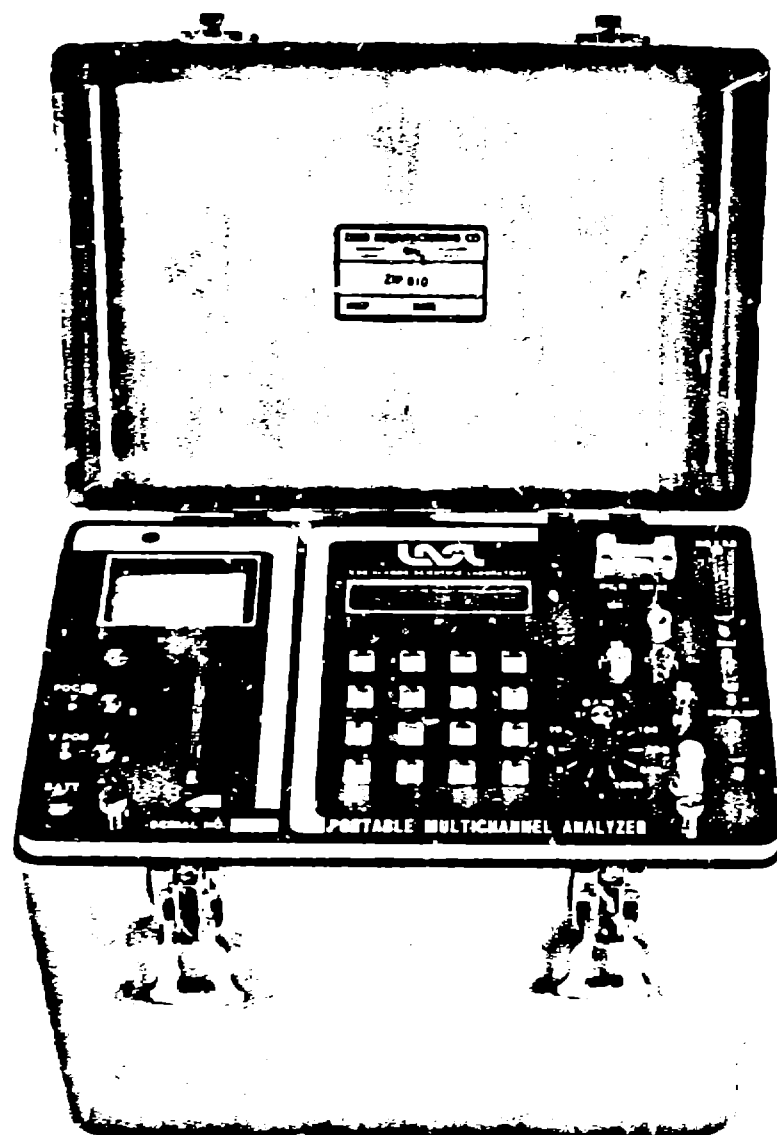


FIG 2

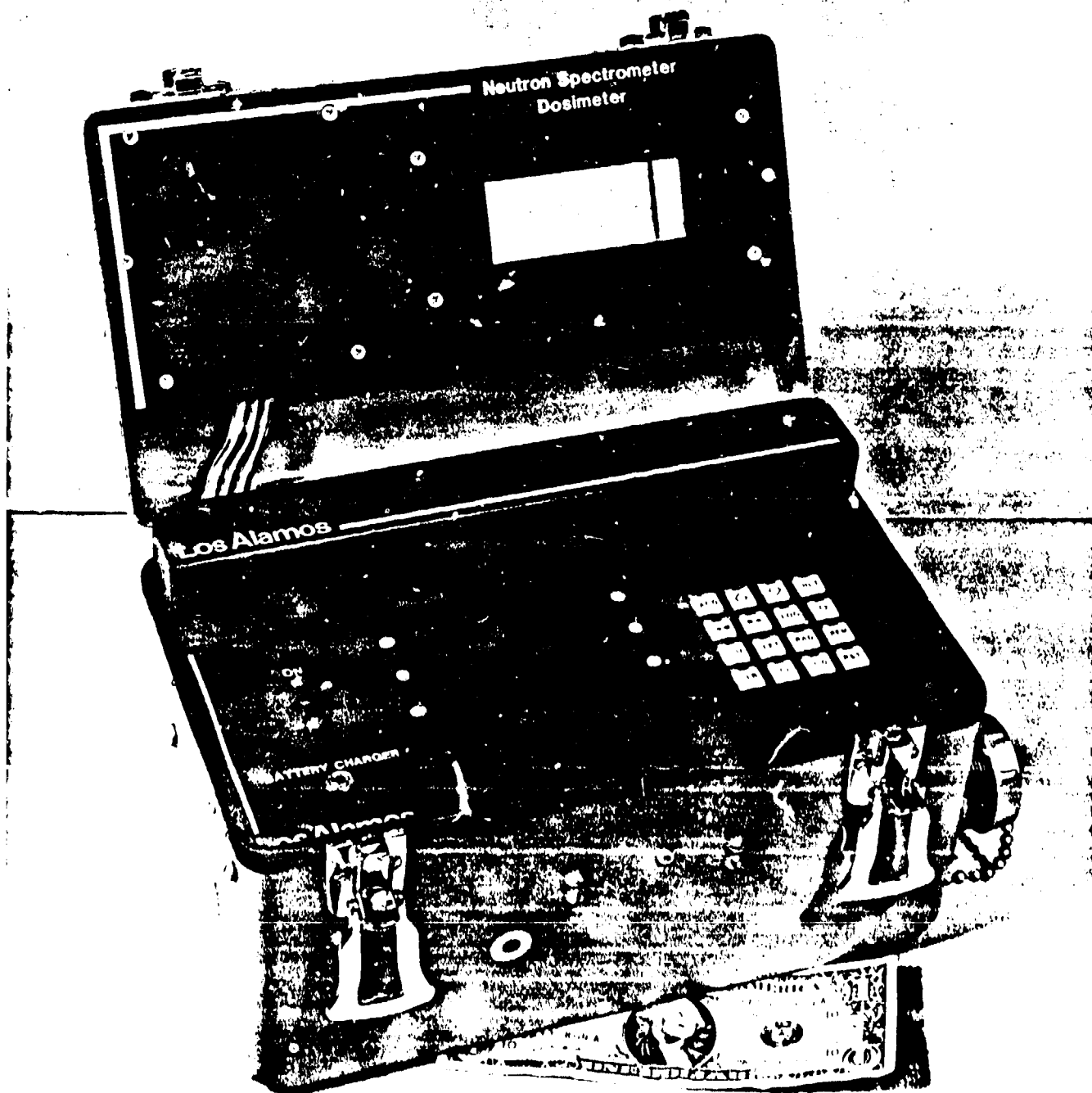


FIG 3



FIG 4



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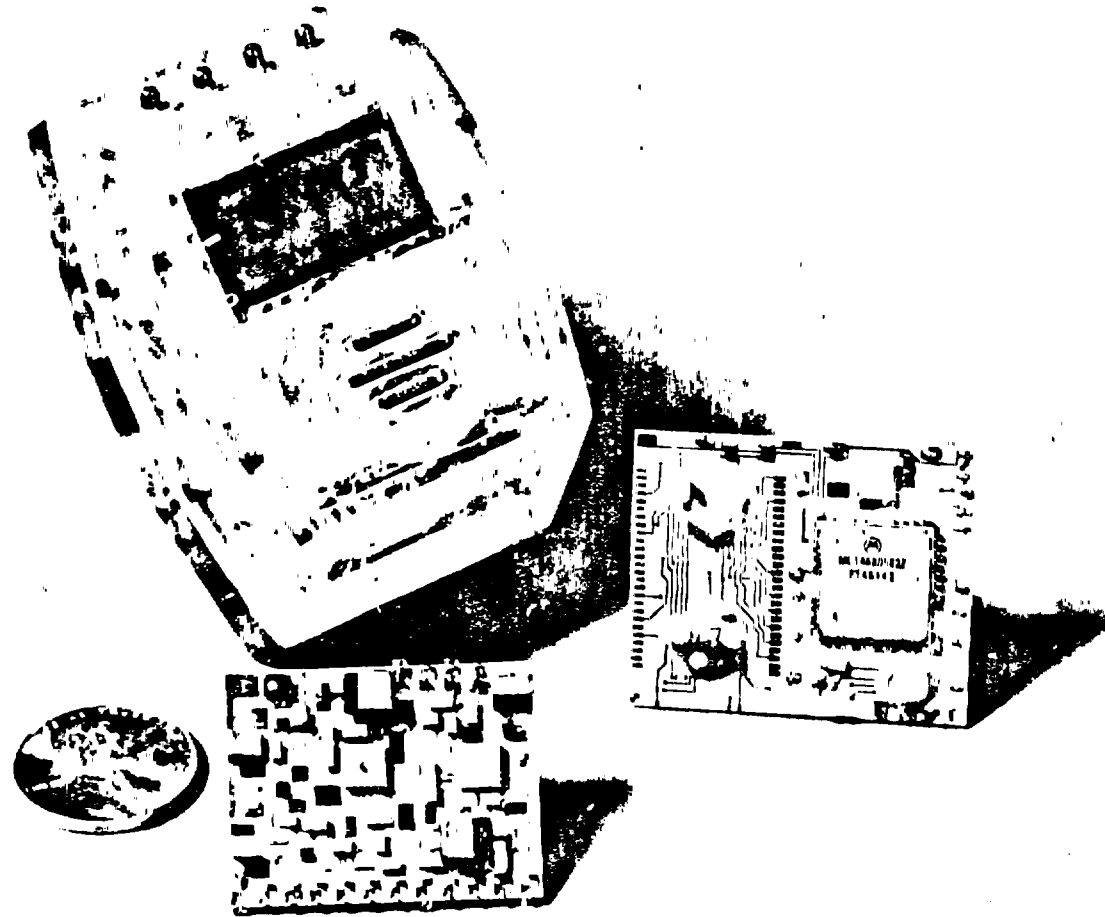


Fig 5

FIG 6

